Chapter 11. Environment, Safety, and Health Considerations

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11.1 Introduction

The Proton Driver, either utilizing a linac or a synchrotron, presents a number of challenges in environment, safety, and health. Here, we identify these challenges and provide a preliminary assessment of how they might be addressed and of their potential impact on the project. While many of these issues are very similar to those that have been encountered and solved during the construction and operation of other facilities at Fermilab and elsewhere, others are novel. The latter will require particular attention as the project proceeds to assure their timely resolution in a cost-effective manner that meets with the approval of the Department of Energy and the public. It is concluded that with adequate planning in the design stages, these problems can be addressed in a satisfactory manner. Future R&D needs related to environment, safety, and health are identified and summarized at the end of the chapter.

11.2 Overall View of Procedural/Regulatory Matters

The actual design, construction, and operation of the Proton Driver will have to meet a number of procedural/regulatory milestones in the area of environment, safety, and health to assure its success. Early attention to these matters is essential. These requirements are provided in Fermilab's Work Smart Standards in Environment, Safety, and Health [1].

11.2.1 Safety and Health Procedural/Regulatory Matters

The Laboratory will be required to prepare an assessment of the environment, safety, and health issues associated with this project in the form of a Safety Assessment Document (SAD). A Preliminary Safety Assessment Document (PSAD) will likely be needed first. Its purpose is to identify the relevant ES&H issues at an early stage and propose how they might be mitigated. The SAD, then, documents the resolution of the issues. DOE may employ an external review team to validate the analysis. Just prior to facility operation, a readiness review will be conducted in similar fashion. PSAD/SAD activities generally begin after funds are released. Fire Safety/Life Safety Code considerations, particularly those concerning egress conditions should be especially carefully thought out prior to the Title I design. DOE is presently "self-regulating" in the areas of industrial safety and occupational radiation protection, a condition that may change in the near-term future with consequences that are unknown at this time.

11.2.2 Environmental Protection Procedural/Regulatory Matters

All DOE projects are subject to the National Environmental Policy Act (NEPA). For a project of this scope, DOE will require an Environmental Assessment (EA). The required analysis is broad in scope and includes societal impacts, such as traffic and noise, along with the standard environmental protection topics. Also included would be investigation of archaeological and historic preservation sites located within the footprint. DOE will choose the methods used to involve the public. The conclusion of the environmental assessment process is either a Finding of No Significant Impact (FONSI) or the need to prepare an Environmental Impact Statement (EIS). The latter choice by DOE is plausible. The decision may hinge on how the Proton Driver is connected with other projects such as a neutrino source or a muon collider. Connection with some larger project, with perhaps more significant environmental impacts, logically will tilt the level of review toward that of an EIS. The completion of the EIS by DOE results in the issue of a formal notice called a Record of Decision (ROD). The process of preparing an EA from the beginning to the publication of the FONSI is estimated to take from one year to 18 months. Two or three years are likely needed, at a minimum, to complete an EIS. NEPA requirements must be completed prior to expenditure of project funds or any “detailed design.”

A significant part of the NEPA process consists of an analysis of alternatives to this proposal, identifying the environmental impacts of all of them, and demonstrating that the proposed project either has the least impact or that the impacts are justified by other considerations. Potential "hypothetical" alternatives must include the “no action” alternative, i.e., "making do" with the present Linac and Booster. Other alternatives that could be considered are to upgrade the present Booster in its current location or to place the Proton Driver in alternative locations on the Fermilab site. Alternative locations may have a substantial effect on the analysis of impacts. For example, locating the project in non-wetland areas (e.g., south of Giese Road, or west of the NuMI access road) may warrant serious consideration if it results in the alleviation of important environmental problems. Furthermore, any decontamination or decommissioning of portions of the accelerator complex that might be replaced by the Proton Driver (e.g., the 8 GeV Booster) should be included in the analysis.

Several environmental permits will be needed. Some of these apply during the construction stages, others apply to operations, and some apply to both. These permits include storm water discharges, discharges of cooling water, wetlands mitigation, releases of air pollutants for both non-radioactive pollutants and for radionuclides, and construction in any floodplains. Existing environmental permits issued to DOE and the Laboratory address some of these issues. However, modifications may be necessary to encompass the construction and operations of the Proton Driver. A prominent example is the need to secure a permit under the National Emissions Standards for Hazards Air Pollutants (NESHAP) to construct a new source of airborne radionuclide emissions [2]. The lead-time required for submittal of these permits is typically 180 days or longer. The permits all come with lists of "terms and conditions", enforceable by the regulatory agencies. It is important that these matters be carefully considered and realistically planned for early in the project to be properly funded to avoid problems later.

11.2.3 Wetlands Impact

The wetland impacts would be major for this project as it is currently envisioned with either choice of machine. At this early stage a great deal of the construction likely would be in jurisdictional wetlands (i.e., wetlands of a size of regulatory importance). Thus, an individual permit from the U.S. Army Corps of Engineers (CoE) must be obtained before the commencement of construction, with a minimum of a one-year lead-time. The permit is certain to require the replacement of the wetland acreage lost “in kind”. Unfortunately, the present wetlands that might be impacted are *forested*, and thus essentially impossible to replace “in kind.” Therefore, a ratio of 2:1 of replaced to lost acres is probable, with the likely necessity to create up to 60 acres of new wetland. The choice of a place on the Fermilab site for such a large wetland should be done carefully, since the new wetland becomes essentially untouchable for development in the future. At the time of this writing, replacement wetland typically costs about $50,000 per acre to build and manage. It must be monitored as a condition of the permit, typically for a period of five years, and failure to meet performance criteria would necessitate remediation. Efforts that can be made to reduce the size of the impacted wetlands are obviously worthwhile. The siting of any new cooling ponds is also a consideration here.

11.3 Environment, Safety, and Health Considerations During Construction

11.3.1 Occupational Safety During Construction of the Facility

These facilities all would be located within the glacial till, where construction is likely to proceed by the familiar "cut and fill" method. The Occupational Safety and Health Administration's (OSHA) regulations on the construction activities will be followed. Industrial radiography operations and any other work conducted using radioactive sources must be performed in compliance with State of Illinois requirements. Other routine radiological issues that might arise will be handled according to the *Fermilab Radiological Control Manual* (FRCM) [3]. Should alternative methods of construction such as underground tunneling be chosen, perhaps in order to minimize the size of impacted wetlands, further review may be necessary.

11.3.2 Environmental Protection During the Construction of the Facility

Erosion control measures similar to those employed elsewhere must be employed in accordance with good engineering practice and Federal and State regulations. Dust and runoff from any spoil piles must be kept under control. A National Pollutant Discharge Elimination System (NPDES) storm water permit for construction will be needed. This will include specific erosion and sedimentation controls that must be followed during the construction period. The usual precautions to prevent pollution from spills of regulated chemicals from the construction equipment will need to be taken. Noise from construction activities is not expected to be significantly more intense than that associated with normal civil construction activities in the vicinity of Fermilab. It is important to demonstrate adequate care for floodplains due to significant local public concerns about flood prevention. Also, due to the fact that Indian Creek runs through the proposed site, it is very likely that the construction would qualify as a "Class III" dam, a condition that would require a permit from the State of Illinois.

11.4. Environment, Safety and Health Considerations During Operation

11.4.1. Occupational Safety Hazards During Operations

The occupational safety hazards encountered at all other large particle accelerator facilities, including the present complex at Fermilab, will be found in this facility:

- The project will use high current electrical circuits in the magnets on a large scale.
- Radio frequency (RF) generation and distribution equipment will be used extensively.
- Large amounts of cables in cable trays, with associated fire protection implications, will be installed.
- Long tunnels will be present with corresponding egress and fire protection issues that need to be addressed.
- There will be movements and alignment of large, heavy components.
- There will be significant amounts of cooling water present.
- Cryogenics and superconductivity hazards will be present, if the linac option is chosen.

These issues have been successfully addressed in the past by the application of well-known technologies and safety practices that will be applied to this new facility. The incorporation of unusual materials in accelerator components or as target materials could pose industrial hygiene issues that will need proper evaluation and mitigation.

11.4.2 Ionizing Radiation Safety During Operation of the Proton Driver

The major issues related to ionizing radiation have been discussed elsewhere in this report and this detailed analysis will not be duplicated here.

11.4.2.1 Prompt Radiation Shielding

The Proton Driver will require massive amounts of hadron shielding similar in scale and type to that of other proton accelerators in this energy and intensity regime. It is clear that suitable combinations of steel, concrete, and earth shielding can meet the standard criteria for above ground shielding at Fermilab.

From the standpoint of machine reliability, it is inconceivable for a catastrophic loss of the full beam to continue for more than a short period of time. Likewise, long-term steady state losses must be kept very small. These limits on beam loss, if adequately analyzed and documented can be used to form the basis of the shielding assessment, which is needed to satisfy a Laboratory requirement [3].

Regulatory [4] and DOE [5] requirements pertain to radiation fields present on a DOE site. While Ref. [4] primarily concerns exposures to occupational workers and Ref. [5] pertains primarily to members of the public, these two standards, both incorporated into Ref. 1, are consistent in that the annual radiation dose equivalent must be kept below 100 mrem in locations where members of the public or employees who have not been specifically trained as "radiation workers" could be present. Fermilab has adopted policies that achieve this condition [3]. If the dose equivalent in an hour resulting from the maximum credible accidental beam loss can be constrained to be less than 1 mrem and if the dose equivalent due to normal operating conditions can be shown to result in a dose equivalent of less than 0.05 mrem per hour , the affected area needs no further controls.

Clearly, passive shielding can be used to achieve these objectives in a detailed design. The passive shielding should also consider muons. Fortunately, at these energies, the forward-peaked kinematical distributions and relatively short ranges (less than about 30 meters of earth) of the muons simplify their shielding. An especially welcome result of this project will be the elimination of the quite troublesome shielding problem associated with the present 8 GeV Booster and certain work places of high occupancy adjacent to it. Care in the detailed design should make it possible to avoid undesirable prompt radiation levels in various support structures by assuring that adequate passive shielding is used. Experience at nearly all accelerators, including the present Fermilab Booster, is that future upgrades nearly always are compromised or made more costly by having "occupied structures" located above or beside the accelerator enclosure. Provision should be made to assure that no such structures are placed at minimal distances from the accelerator enclosures. This is needed to avoid unnecessary constraints being placed on operations, necessitated by unexpected levels of beam loss. Otherwise, operational difficulties are likely due to the need to control radiation exposures in work places much more stringently than those required in "uncontrolled" areas, where one has options such as fencing available as fallback positions.

11.4.2.2 Residual Radioactivity of Components

Efforts should be made to keep residual radiation levels at contact with the beam pipe in unshielded portions of the lattice to less than approximately 100 mrem per hour while those at contact with magnets, etc. should be less than about 10 mrem per hour. This may require the achievement of average beam losses that are very small. The coupling of this issue with prompt radiation shielding is obvious. At levels of these magnitudes, the control of occupational radiation exposure during routine maintenance activities is possible, but difficult. To maintain total exposures to maintenance personnel at acceptable levels, considerations of maintenance activities in the design with a view toward keeping exposures as low as reasonably achievable (ALARA) is a necessity. Both residual and prompt radiation considerations are of sufficient importance to require continuous attention to beam loss during operations and careful planning of maintenance activities in order to keep occupational radiation exposures as low as reasonably achievable, in compliance with regulatory compliance [Ref. 4].

11.4.2.3 Airborne Radioactivity

Airborne radioactivity levels will largely be encountered either in areas where collimators are employed to limit beam loss or at the target stations (note: Target stations are discussed in Chapter 21) The design of the collimation system will include a calculation of the airborne radioactivity released, to support the permit requirements outlined in Section 11.2.2 and to assure compliance with regulations governing airborne radionuclide releases found in Ref. [2]. An early assessment of this issue will allow the inclusion of mitigation into the design of the facility.

11.4.2.4 Radioactivity in Soil and Groundwater

As the shielding design proceeds, the production of radioactivity in soil and the consequences of its migration to groundwater resources must be carefully considered so that the regulatory requirements of Ref. [1] are met. For "ordinary" sections of machine lattices, the allowable amounts of beam loss, especially those expected on a steady-state basis, need to also be compatible with the needs of prompt radiation levels external to the shielding and residual activity levels within the enclosure. Depending on the analyses of radioactivation of soil/groundwater, monitoring wells may be in place, requiring a sampling and maintenance schedule. These considerations are quite similar to those encountered at other Fermilab facilities located in the glacial till.

11.4.3 Non-Radiological Environmental Protection Issues During Operations

Efforts should be made to prevent the creation of regulatory mixed wastes and to control spills. Surface water discharges must be managed in accordance with Laboratory policies and any State and Federal environmental permits that are in place.

The cooling water requirements for the Proton Driver synchrotron are significant. These requirements should be examined to determine if the impact on Fermilab's industrial cooling water (ICW) system and any new discharges to "waters of the state" (i.e., Indian Creek) requires modifications to the Laboratory's current National Pollutant Discharge Elimination System (NPDES) permit under which these systems are operated. Any chemical additives to these systems must be approved within the framework of existing permits.

11.5 Summary

The Proton Driver provides a number of challenges in the area of environment, safety, and health. Many of these have been encountered, and effectively addressed, at Fermilab and other accelerators. Some of the problems are common to technological advances in other accelerators worldwide. For these, collaborative efforts should continue to develop and improve the solutions. This project raises a few new issues that must be addressed. Continued attention to these issues is anticipated as the project proceeds.

11.6 Need for Work on Environmental and Safety Issues

A. The Fire Safety/ Life Safety Code considerations need to be carefully addressed prior to Title I design (Section 11.2.1).

B. The needed environmental permit applications should be developed and submitted at the earliest possible stage (Sections 11.2, and 11.3.2). Specific time requirements for each permit application process are available from the ES&H section, but all permits must be assumed to take at least 180 days.

C. The alternatives to be studied as part of the NEPA process must be identified (Section 11.2.2).

D. Archaeological/historic sites within the footprint project will need to be surveyed (Section 11.2.2).

E. The potential size/type of impacted wetlands and floodplains should be further investigated before the "footprint" of the project becomes completely defined by other constraints (Section 11.2.3). Modifications to the footprint should be considered that would minimize the impacted areas.

F. The cost of environmental compliance, maintenance, monitoring, and oversight must be included explicitly in early planning/budgeting processes. This is especially true for projects of this magnitude, where such costs could be several million dollars, and the efforts needed extend for years beyond actual construction. Significant funds may also be necessary to complete studies for preliminary environmental work (e.g., wetland delineations, wildlife surveys, groundwater investigations) prior to project funding *per se* (Sections 11.2.2, 11.2.3, and 11.3.2).

G. The trade-off between control of beam loss and additional lateral shielding needs to be better understood (Section 11.4.2.1).

H. The support structures should be located so that they are not above any part of the accelerator enclosures and are shielded by more than "the minimum" amounts of lateral shielding to allow for uncertainties in shielding calculations and to accommodate future upgrades (Section 11.4.2.1).

I. Calculations of airborne radionuclide releases are needed concerning the beam collimation system to establish permitting requirements and demonstrate that operations will be within established regulatory requirements (Section 11.4.2.3).

J. A hydrogeological survey in the vicinity of the planned facility should be conducted to better refine the parameters relevant to groundwater activation prior to the finalization of the design (Section 11.4.2.4).

References

[1] "Fermilab Work Smart Standards Set," Fermi National Accelerator Laboratory, http://www-lib.fnal.gov/library/worksmart/worksmart.html, current version.

[2] United States Code of Federal Regulations, Title 40, Part 61, Subpart H, "National Emissions Standard for Hazardous Air Pollutants (NESHAP) for the Emission of Radionuclides other than Radon from Department of Energy Facilities," current version.

[3] *Fermilab Environment, Safety, and Health Manual,* and *Fermilab Radiological Control Manual*, http://wwwesh.fnal.gov/pls/default/esh_home_page.page?this_page=10, current version.

[4] United States Code of Federal Regulations, 10 CFR 835, "Occupational Radiation Protection," current version.

[5] DOE Order 5400.5, "Radiation Protection of the Public and the Environment," January 1993.